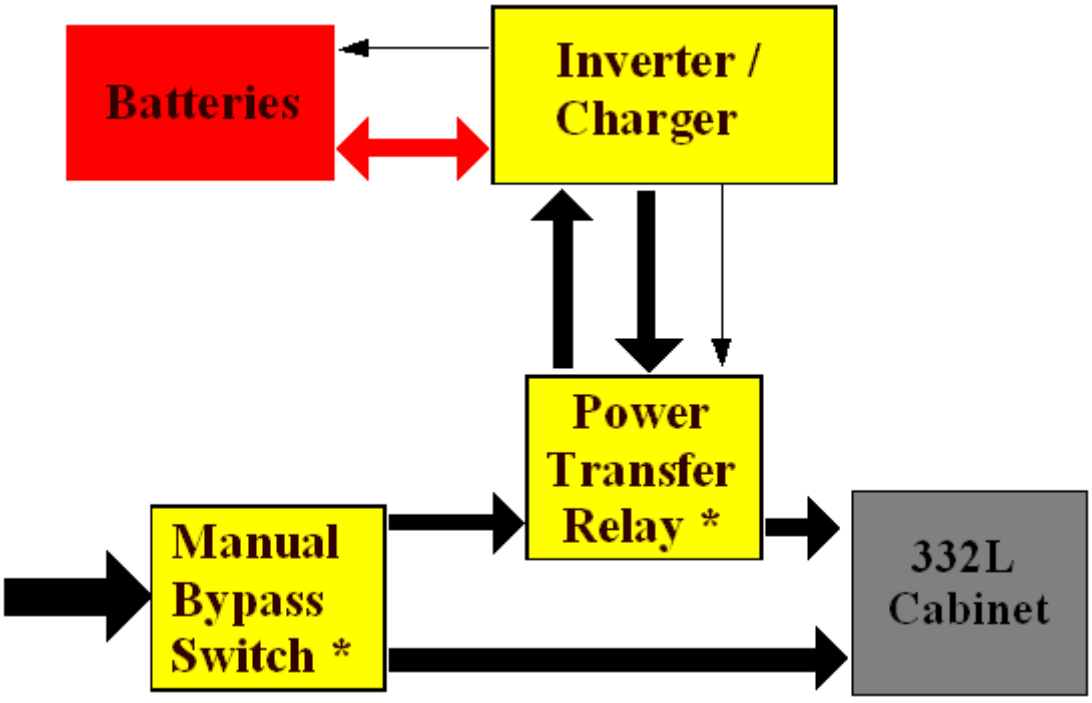
TEES

CHAPTER 4

SPECIFICATIONS FOR BATTERY BACK-UP SYSTEM



Department of Transportation

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Specification for Battery Back-up System
For Traffic Signals utilizing
Light Emitting Diodes (LED) Traffic Signal Modules:

GENERAL

This specification establishes the minimum requirements for a complete emergency battery backup system for use with Light Emitting Diode (LED) Traffic Signal Modules. The Battery Backup System (BBS) shall include, but not be limited to the following: Inverter/Charger, Power Transfer Relay, a separate manually operated non-electronic Bypass Switch **(See Figure 1 – BBS Block Diagram)** and all necessary hardware and interconnect wiring. The BBS shall provide reliable emergency power to a traffic signal system (Vehicle and Pedestrian Traffic) in the event of a power failure or interruption.

The BBS shall be capable of providing power for full run-time operation for an "LED-only" intersection (all colors: red, yellow, green and pedestrian heads) or flashing mode operation for an intersection using Red LED's.

The BBS shall be designed for outdoor applications, in accordance with the Caltrans Transportation Electrical Equipment Specifications (TEES), dated March 12, 2009, Chapter 1 requirements.

1. OPERATION

1.1 Compatibility

The BBS shall be compatible with NEMA, Caltrans 332L Cabinets, Model 170E Controllers, Model 2070 Controllers and cabinet components for full time operation.

1.2 Run-Time

The BBS shall provide a minimum two (2) hours of full run-time operation for an "LED-only" intersection.

1.3 Output Capacity

The BBS shall be able to provide a minimum of 1000W @ +25ºC, continuous active output capacity, with 80% minimum inverter efficiency while running in Backup Mode (on batteries).

1.4 Output Voltage

When operating in Backup mode, the BBS output shall be 120 VAC ± 5 VAC, pure sine wave output, ≤ 3% THD, 60 Hz ± 0.05 Hz.

1.5 DC System Voltage

The BBS DC system voltage shall be either 24 VDC or 48 VDC.

1.6 Transfer Time

The maximum transfer time allowed, from disruption of normal utility line voltage to stabilized Backup Mode line voltage, shall be no greater than 40 milliseconds. The same maximum allowable transfer time shall also apply when switching from Backup Mode line voltage back to utility line voltage.

1.7 Operating Temperature

The operating temperature for the inverter/charger, power transfer relay and manual bypass switch shall be –37 °C to +74 °C. Additionally, all components and parts used shall, at the very least, be rated for that temperature range.

1.8 AC Feedback

The BBS shall be equipped to prevent a malfunction feedback to the cabinet or from feeding back to the utility service.

1.8.1 Feedback Level

In the event that the AC service feeding the BBS is severed, or there is a utility black-out, the AC voltage measured at the AC inputs to the BBS (Line to Neutral), shall be less than 1 VAC.

1.9 Surge Protection

The BBS shall have lightning surge protection compliant with IEEE/ANSI C.62.41 and must be able to withstand 2000 volt surges applied 50 times across line and neutral. These surges shall not cause the BBS to transfer to Backup mode.

1.10 Power & Control Connections

The BBS shall be easily installed, replaced, or removed by using easily removable cables for AC input , AC output, DC input, external transfer relay control and battery temperature sense.

1.10.1 AC Connection

The AC input and output shall be panel mounted plug / receptacles that allow no possibility of accidental exposure to dangerous voltages (male receptacle for AC Input and female receptacle for AC Output). The receptacles shall utilize some form of locking mechanism or hold down clamps to in order to prevent any accidental disconnects.

1.10.2 DC Connection

The DC connection shall be a recessed one or two piece Anderson style receptacle.

1.10.3 Relay / Temperature Probe Connections

The external power transfer relay control and the battery temperature sense inputs shall be heavy duty panel-mounted style connectors.

1.10.4

All connections shall provide mechanically and electrically secure connections without the use of a screwdriver. The only exception will be the 18-position Relay Terminal Block which shall require a small screwdriver for holding down the relay wires.

1.11 Relay / Switch Ratings
The Power Transfer Relay and Manual Bypass Switches shall be rated at 240VAC/30 amps, minimum.

1.12 Unit Failure
In the event of inverter/charger failure, battery failure or complete battery discharge, the power transfer relay shall revert to the NC (and de-energized) state, where utility line power is connected to the cabinet.

1.13 Overload
The BBS must be able to shutdown in order to protect against internal damage in the event of an overload at the output.

1.14 Bypass
Placing the Manual Bypass Switch into "Bypass" shall cut AC Utility power to the Inverter/Charger and route it directly to the 332L Cabinet. In this condition, if the inverter is then disabled and the batteries disconnected from the system, the Inverter/Charger unit shall be completely de-energized and shall be safe to remove from the intersection system, while still allowing the intersection to function normally.

2. FUNCTIONALITY, DISPLAYS AND CONTROLS

2.1 Normal & Generator "Standby" Modes
There shall be two user adjustable "Standby" modes. These modes will be "Normal" and "Generator". In these modes, the utility AC voltage shall be passed directly to the output. The system will transfer to Backup mode at user defined, low and high cutoff voltage level transfer set points that are adjustable between 90 and 135 VAC (the default shall be 100 and 130 VAC). The BBS will automatically apply a 5 VAC difference for the return transfer points.

2.1.1 Low & High Cutoff
When the BBS is in "Normal" or "Generator" modes (Buck / Boost is Disabled), the BBS shall bypass the utility line power whenever the utility line voltage is outside of the transfer set points (± 2 VAC).

2.1.2 Low Restore
In cases of low (below the low voltage transfer set point), or absent utility line voltage, when the utility line voltage has been restored at or above 5 VAC ± 2 VAC of the low transfer set point for more than 30 seconds (or the user configured line qualify time), the BBS shall transfer from Backup Mode back to Utility Line Mode.

2.1.3 High Restore
In cases of high (above the high voltage transfer set point) utility line voltage, when the utility line voltage has been restored at or below 5 VAC ± 2 VAC of the high transfer set point for more than 30 seconds (or the user configured line qualify time), the BBS shall transfer from Backup Mode back to Utility Line Mode.

2.2 Buck / Boost "Line-Interactive" Mode

The Buck / Boost mode of the BBS shall have a range of 90 – 150 VAC. There shall not be any user configurable transfer set point for the Buck / Boost mode. Whenever Buck / Boost mode is selected, the output of the system shall be regulated between 100 – 130 VAC. When the output of the system can no longer be maintained within that range, the BBS shall transfer to Backup Mode.

2.3 Line Qualify Time

The BBS shall have a user adjustable line qualify time. There will be a minimum of three (3) settings possible. The minimum settings shall be 3 seconds, 10 seconds, and 30 seconds. The default value shall be 30 seconds.

2.4 Display

The BBS shall have a backlit LCD type display that is easily seen in both bright sunlight and in darkness. The screen shall be large enough to display the following minimum information on a continuous basis; operating mode (Normal, Generator, Buck/Boost), utility input voltage, BBS output voltage, charger status, percent battery charge, battery voltage, BBS status (Standby, Backup, Buck, Boost), any alarms and faults, and relay status information.

2.5 Keypad

The BBS shall use a well defined keypad that includes arrow, enter and escape keys so that the user can efficiently navigate the menu system to make system programming changes and gather other status information.

2.6 Status LED's

In addition to the LCD display the BBS shall use three (3) discreet status LED's. The purpose of these LED's is to draw the user's attention to the LCD.

2.6.1 Green "Output" LED

This LED will be ON any time that the output of the BBS is modified, either by Backup Mode, or by Buck / Boost Modes.

2.6.2 Red "Fault" LED

This LED will be ON any time that there are any faults in the system.

2.6.3 Yellow "Alarm" LED

This LED will be ON any time that there are any alarms in the system.

2.7 Event Log & Counters

The BBS shall keep track of the number of times that the unit was in Backup, Buck and Boost modes and the total number of hours and minutes that the unit has operated in those modes since last reset. This information shall be displayed through the LCD.

The BBS shall also keep a running event log with a minimum of 200 latest events. For each event, the log shall contain as a minimum, a date/time stamp, the current operating mode, and what the event was.

2.8 Programmable Relay Contacts

The BBS shall provide the user with six (6) programmable dry relay contacts. These relay contacts shall be rated for a minimum of 1 amp @ 125 VAC. When any relay is energized, it shall show up on the main screen of the LCD. As a minimum, the programming options will be, On Battery, Low Battery, Timer, Alarm, Fault, and Off.

2.8.1 On Battery Relay Contacts

The dry relay contacts that are configured for "On Battery" shall only energize when the Inverter is operating in Backup Mode.

2.8.2 Timer Relay Contacts

The BBS shall have a timer that will energize the dry relay contacts (when configured for "Timer") after the user configured time has elapsed. This timer is started when the BBS in the Backup mode. The user can configure the timer from 0 to 480 minutes, in a minimum of 15 minute increments. The default setting will be 120 minutes.

2.8.3 Low Battery Relay Contacts

The BBS shall have an adjustable low battery relay setting. This setting shall be adjustable so that the user can set the point at which the low battery relay energizes. This setting applies to any dry contact relay that is configured for "Low Battery".

2.8.4 Relay Contact Terminals

The relay contacts shall be made available on the front panel of the BBS via an 18-position, screw hold-down, printed circuit board mounted terminal block. Additional terminals are allowed so long as they are adequately identified and labeled.

2.8.4.1 Terminal Type

The relay contact terminal blocks shall conform to On-Shore Technology, type ED2200/22, or Phoenix Contact type FRONT 2,5-H/SA 5, or WECO type 180-A-111, or equivalent. The spacing between each terminal shall be 0.197" (5 mm), with the hold-down screw and wire entrance both on the same face, facing forward and in the horizontal axis. See **Figure 3** for additional information.

2.8.4.2 Contacts

Each relay shall have their own common and their own set of normally open (NO) and normally closed (NC) terminals. The terminals for each relay shall be oriented as NO-C-NC, on the terminal block.

2.8.4.3 Labeling

The contacts of the terminal block shall be labeled 1…18, left to right. Additionally, each set of contacts shall be labeled with the NO-C-NC designation, as well as C1…C6, again, from left to right. Any remaining contacts on the terminal block shall be labeled as "Spare", unless used for some other purpose, in which case they shall be labeled as to their actual use.

2.9 Ventilation
There shall be adequate clearance in front of all BBS intakes and exhaust vents, and fans. Specifically, any venting on the back panel must be able to maintain adequate airflow through the Inverter/Charger, by utilizing a method to prevent the back panel from being placed directly against the cabinet enclosure.

2.10 Battery Voltage Jacks
There shall be standard meter probe (0.08") input jacks (+RED) and (– BLACK) made available on the BBS front panel used to measure battery voltage externally.

2.11 Circuit Breakers
The BBS shall be equipped with both Input and Output AC circuit breakers, and with either a DC circuit breaker or fused battery harness.

2.12 Battery Charger
The BBS shall have an integral charger. The charger shall be a 3-step "Smart Charger" utilizing bulk, absorption and float charging techniques, appropriate for the battery type. The charger must prevent destructive discharge and overcharge.

2.12.1 Battery Type
The user shall be able to select either "Gel" or "AGM" type batteries. The integral charger shall automatically adjust the charging levels for whatever type battery is selected. The default setting shall be for "AGM".

2.12.2 Temperature Compensation
The integral 3-Step "Smart Charger" shall use temperature compensation. The charging system shall compensate over a range of 2.5 – 4.0 mV/cell/ºC.

2.12.3 Temperature Probe
A temperature sensor probe which plugs into the front panel of the BBS shall be used to monitor the internal temperature of the batteries. The temperature sensor wiring shall be at least 6'6" in length. The sensor shall be imbedded in a heavy duty 3/8" ring lug which can then be attached to one of the battery terminal posts.

2.12.4 Battery Temperature
The batteries shall not be recharged whenever the battery temperature exceeds 50ºC.

3.0 BATTERY HARNESS

3.1 Wiring Type
All battery harness interconnect wiring shall be via a two-part modular harness consisting of UL Style 1015 CSA TEW or Welding Style Cable, or equivalent. Wiring shall be of proper gauge with respect to design current and with sufficient strand count for flexibility and ease of handling.

3.2 Power Pole Connectors
Cable assembly shall be equipped with insulated, mating, one or two-piece Power Pole style connectors. When two-piece Power Pole style connectors are used, the positive terminal (+) shall be red, and the negative terminal (–) shall be black. Additionally, the two-piece connectors shall us a locking pin to prevent the connectors from separating.

3.3 Harness Construction
The Battery Harness and all Power Pole connectors shall be assembled to ensure proper polarity and circuit configuration throughout the entire harness.

3.4 Harness Part I – Battery Side
Part I of the harness shall consist of appropriate lengths (~12") of appropriately colored (black for negative terminal, red for positive terminal), cable with 3/8" ring lug terminals on one end, for connecting to the battery terminals, and the appropriately colored one or two-piece power pole connector on the other side.

3.5 Harness Part II – BBS Side
Part II of the harness shall consist of multiple insulated power pole connectors for mating to the battery side harness (Part I), and a single insulated power pole connector for connecting to the BBS unit.

3.6 Harness Length
The harness length shall be a minimum of 12 inches between batteries and 72 inches between BBS unit and the first battery.

4.0 MOUNTING / CONFIGURATION

4.1 EIA 19" Rack
All references mad to EIA rail or EIA 19" rack shall conform to Electronic Industries Standards EIA-310-D, Racks, Panels, and Associated Equipment with 10-32 "Universal Spacing" threaded holes.

4.2 Mounting Method and Space
The BBS shall be able to be shelf mounted or rack mounted on an EIA rail. The available space (Caltrans External BBS Cabinet) is 17.75 inches wide, 10.25 inches deep, and 12" high.

4.3 BBS Dimensions
The entire BBS, including the Inverter/Charger, Power Transfer Relay and Bypass Switch Assembly must be able to fit on the EIA rail and shelf in the dimensions specified above. Inverter/Charger dimensions shall be no greater than 17.5"W x 10.25"D x 6.0"H and with EIA mounting brackets attached must be able to install on the EIA rails.

4.4 Included Hardware
All necessary hardware for mounting shall be included in the bid price of the BBS. This shall include EIA mounting brackets, bolt and washers, cable ties, and adhesive backed panel-mount style cable tie holders.

4.4.1 Bolt and Washer Requirements

Bolts and washers shall meet the following requirements:

- Screw Type: Pan Head Phillips machine screw
- Size and Thread Pitch: 10-32
- Material: 18-8 stainless steel (Type 316 stainless steel is acceptable as an alternate)
- Washer: Use one flat washer (18-8 stainless steel) under the head of each 10-32 screw

4.4.2 Cable Ties and Cable Tie Holders

The amount and size of cable ties and the adhesive backed panel-mount style cable tie holders shall be adequate for the wire size of the particular BBS and be of sufficient quantity to neatly dress the full length of provided wire inside of External BBS Cabinet and/or 332L Cabinet.

4.5 Interconnect Wiring

All interconnect wiring shall be provided between Power Transfer Relay, Bypass Switch, and 332L Cabinet Terminal Service Block. This wiring shall be no less than 9' of UL Style 1015 CSA TEW with the following characteristics:

- AWG Rating: 10 AWG
- Stranding: 105 strands of 30 AWG tinned copper
- Rating: 600 V, 105ºC, PVC Insulation

4.6 Relay Contact Wiring

Three (3) sets of relay contact wiring shall be provided. Each set shall be two twisted insulated conductors of UL Style 1015 CSA TEW 18 AWG wire, same ratings as above, except 16 strands of 30 AWG tinned copper.

4.7 Transfer Relay / Bypass Switch

The Power Transfer Relay and Bypass Switch Assemblies may either be discreet from one another, or they may be combined into one assembly.

4.8 Transfer Relay

There is also the option of the Power Transfer Relay being internal to the Inverter portion of the BBS. The Bypass Switch will always remain a separate and discreet assembly.

5.0 COMMUNICATIONS

The BBS shall have RS-232 and Ethernet communications as standard.

5.1

All BBS Configuration and System menus shall be accessible and programmable from the RS-232 port and from the Ethernet port. Additionally, all log files shall be available through these ports.

5.2

The RS-232 ports shall be set for a standard off-the-shelf RS-232 Cable.

5.3
The Ethernet IP address shall be user configurable.

6.0 WARRANTY

Manufacturers shall provide a five (5) year warranty. The first three (3) years shall be termed the "Advanced Replacement Program". Under this program, the manufacturer will send out a replacement within two business days of the call notifying them of an issue. The replacement unit may be either a new unit or a re-manufactured unit that is up to the latest revision. The last two years of the warranty will be factory-repair warranty for parts and labor on the BBS.

7.0 QUALITY ASSURANCE

7.1
Each BBS shall be manufactured in accordance with a manufacturer Quality Assurance (QA) program. The QA program shall include two Quality Assurance procedures: (1) Design QA (see 7.4 below) and (2) Production QA. The Production QA shall include statistically controlled routine tests to ensure minimum performance levels of BBS units built to meet this specification and a documented process of how problems are to be resolved.

7.2
QA process and test results documentation shall be kept on file for a minimum period of seven years.

7.3
Battery Backup System designs not satisfying Design QA Testing and Production QA Testing requirements shall not be labeled, advertised, or sold as conforming to this specification.

7.4 DESIGN QUALIFICATION TESTING

7.4.1 Design Changes

The manufacturer, or an independent testing lab hired by the manufacturer, shall perform Design Qualification Testing on new BBS system(s) offered, and when any major design change has been implemented on an existing design. A major design change is defined as any modification, either in material, electrical, physical or theoretical, that changes any performance characteristics of the system, or results in a different circuit configuration. Where a dispute arises in determining if a system is a new design or if the system has had a major design change, the State will make the final determination if Design Qualification Testing is required prior to production consideration.

7.4.2 Submittals

A quantity of two units for each design shall be submitted for Design Qualification Testing.

7.4.2.1
Test units shall be submitted to Caltrans TransLab, Electrical Testing Branch after the manufacturer's testing is complete.

7.4.2.2 Test Data Submittal
Manufacturer's testing data shall be submitted with test units for Caltrans verification Design Qualification Testing.

7.4.3 Burn-In
The sample systems shall be energized for a minimum of 5 hours, at full rated load, at temperatures of +74 °C and –37 °C, excluding batteries, before performing any design qualification testing.

7.4.4
Any failure of the BBS, which renders the unit non-compliant with the specification after burn-in, shall be cause for rejection.

7.4.5 Testing
For Design Qualification Testing, all specifications will be measured including, but not limited to:

7.4.5.1
Minimum of two hours of run time while operating in Backup Mode, at full load.

7.4.5.2
Proper operation of all relay contacts

7.4.5.3
Inverter output voltage, frequency, harmonic distortion, and efficiency, when in Backup Mode.

7.4.5.4
All power transfer voltage levels and all modes of operation.

7.4.5.5
Power transfer time from loss of utility line voltage to stabilized inverter line voltage from batteries.

7.4.5.6
Backfeed voltage to utility when in Backup Mode.

7.4.5.7
IEEE/ANSI C.62.41 compliance.

7.4.5.8
Battery charger operation.

7.4.5.9
Event counter and runtime meter accuracy.

7.4.5.10
Ability to control, monitor, get reports, and configure the system through the standard RS-232 and Ethernet ports.

7.4.5.11
Complete physical inspection of the system for quality workmanship.

7.5 PRODUCTION QUALITY CONTROL TESTING

7.5.1
Production Quality Control tests shall consist of all of the above listed tests and shall be performed on each new system prior to shipment. Failure to meet requirements of any of these tests shall be cause for rejection. The manufacturer shall retain test results for seven years.

7.5.2
Each BBS shall be given a minimum 100-hour burn-in period to eliminate any premature failures. The burn-in period can be a combination of running in Backup Mode with a full load and running in Charger Mode.

7.5.3
Each system shall be visually inspected for any exterior physical damage or assembly anomalies. Any defects shall be cause for rejection.

7.6 CALTRANS QUALITY ASSURANCE TESTING

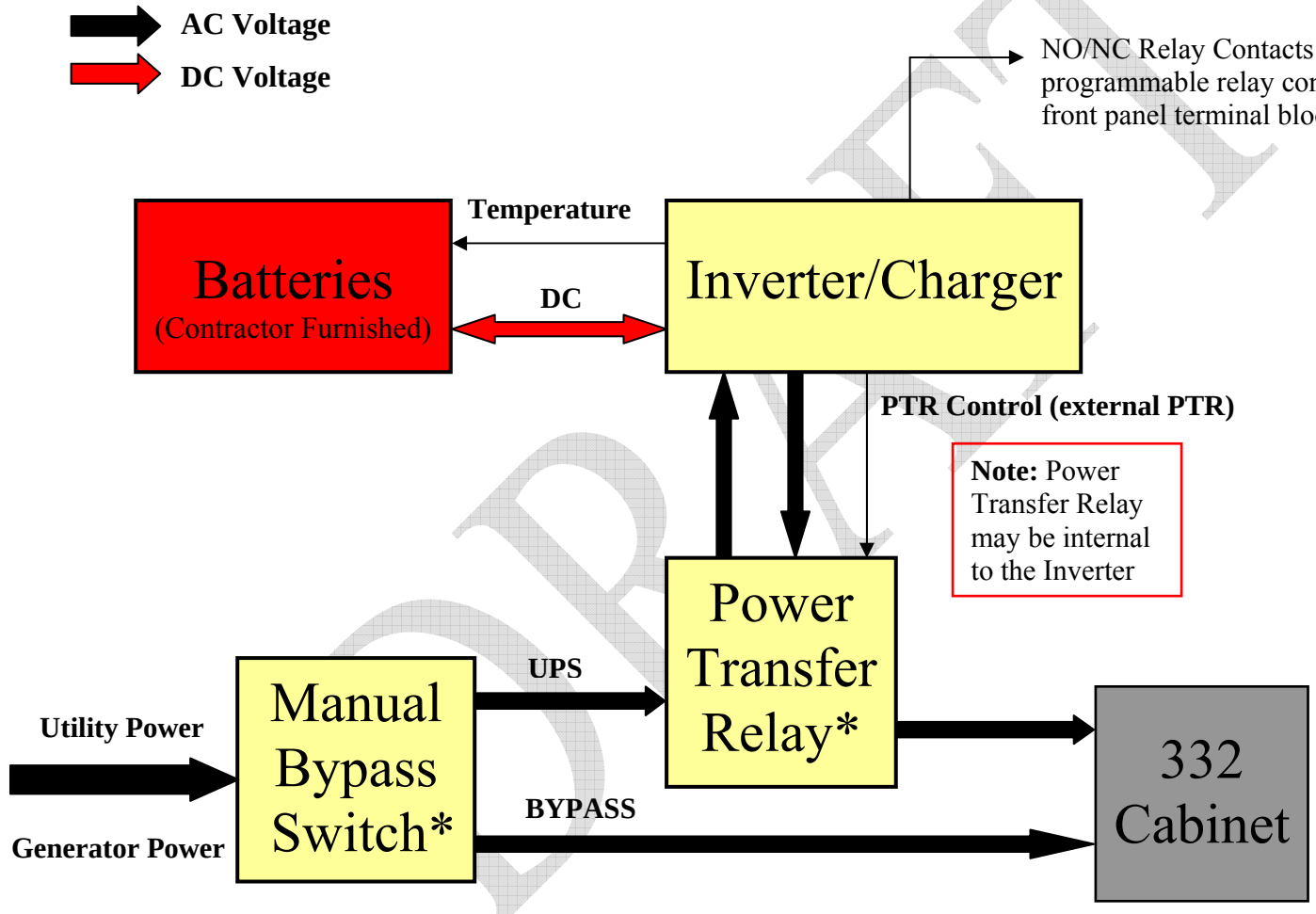
7.6.1
Caltrans will perform random sample testing on all shipments, consistent with ANSI/ASQC Z1.4-1993 Sampling Procedures and Tables for Inspection by Attributes.

7.6.2
Sample testing will normally be completed within 30 days after delivery to the Caltrans Laboratory, barring deficiencies in the shipment, which would reset the clock.

7.6.3
All parameters of the specification may be tested on the shipment sample.

7.6.4
The number of units tested (sample size) shall be determined by the quantity in the shipment. The sample size and acceptance or rejection of the shipment shall conform to ANSI/ASQC Z1.4.

Battery Back Up System(BBS) Block Diagram



* Manual Bypass Switch (must be external to Inverter), and Power Transfer Relay must be separate functional units, but may share a common enclosure.

Figure 1

BBS Utility Power Connection Diagram

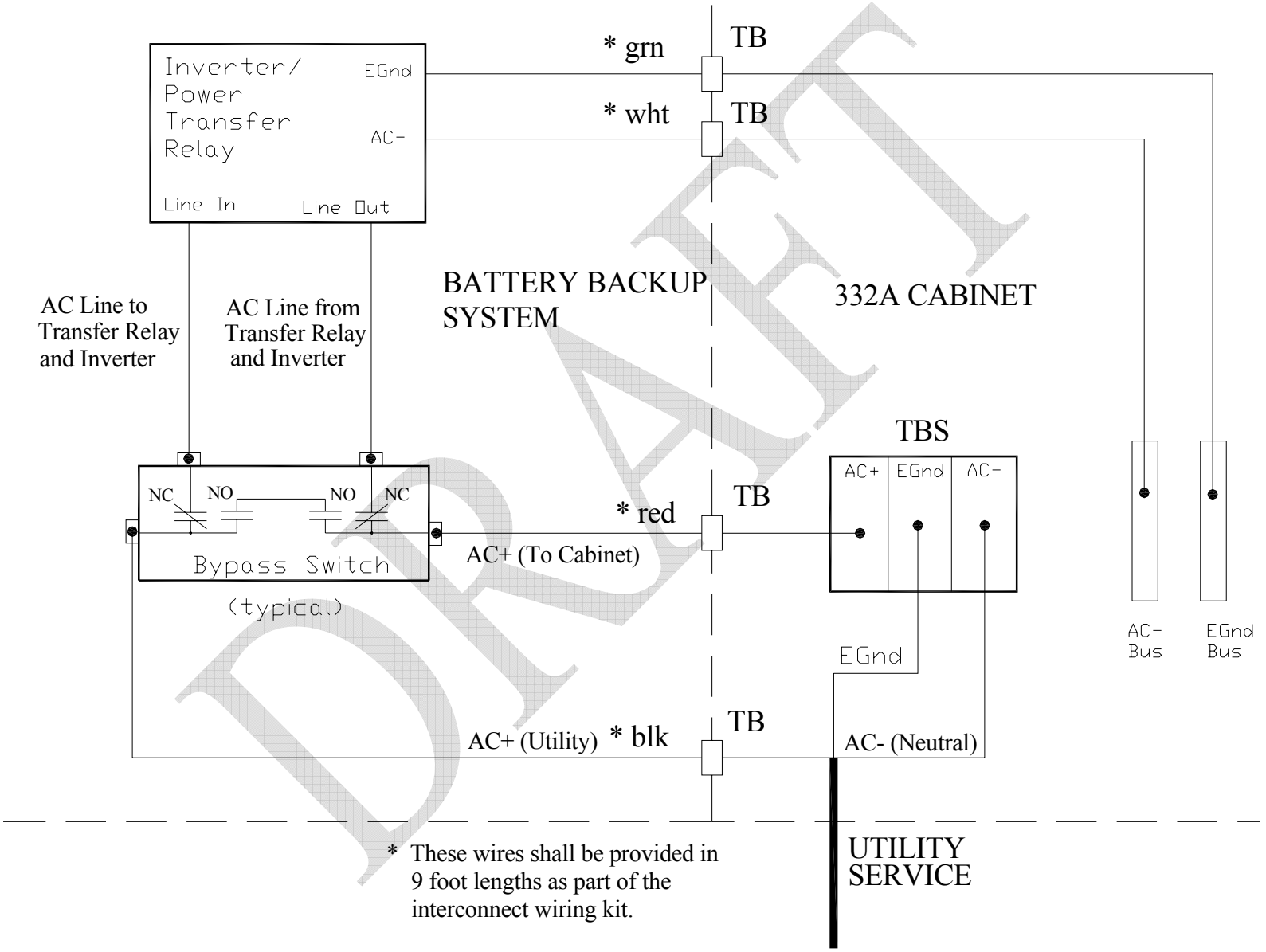
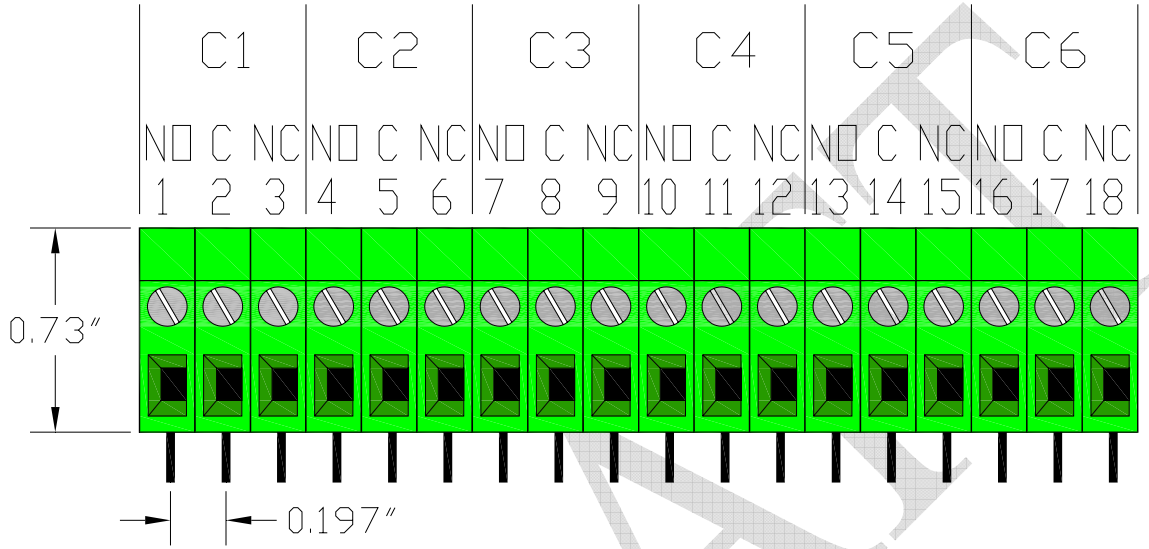


Figure 2



Relay Contact Terminal Block:

- Available on Front Panel of Inverter/Charger
- 0.197” (5mm) spacing
- Allows wire size 24 – 12 AWG
- Screw and wire entrance are on the same face

Figure 3